Physical Influences on Satellite-Based Sea Surface Temperature Measurements and Uncertainties

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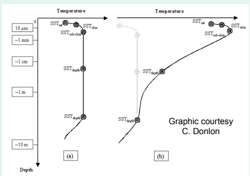
Motivation

While sea surface temperature (SST) retrievals are widely utilized, many components of the uncertainty budget are still poorly understood and various physical processes are not directly accounted for in many current products. This work to improve and better quantify the accuracy of satellite SST products is being conducted through partnership with NESDIS, NASA, the Navy, and academia. Key applications include multi-sensor blended products, air-sea fluxes, and bias-free climate records.

The Problem: What is SST?

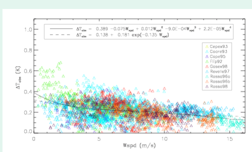


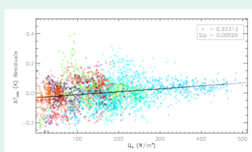
Air-sea interactions and near-surface processes result in strong temperature differences at the ocean surface both as a function of time and depth. Various sensors measure at different times and effective measurement depths requiring these temperature variations to be understood.

Skin Layer Effects

The ocean skin is typically cooler than the water just below the surface due to heat loss from this thin layer to the atmosphere. Accounting for this difference is important for the computation of air-sea fluxes and validation of satellite observations.

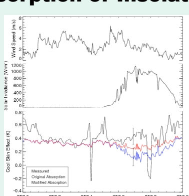
Improving Models for Skin Layer Cooling

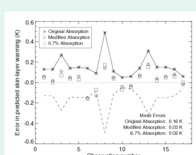




Simplified parameterizations suggest that the skin layer cooling can be approximated solely from the wind speed, but residual dependencies on the heat flux across the interface exist and should be accounted for.

Absorption of Insolation Within the Skin Layer





Refinements corrected for overestimates of absorption within the skin layer in early versions of the COARE model, reducing anomalous surface warming.

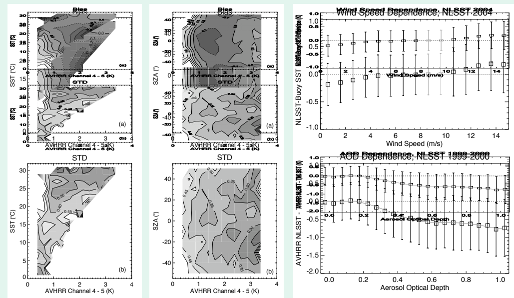
Acknowledgments

Portions of this work were supported through the National Ocean Partnership Program and NASA. Additional contributions of data and ideas from Christopher Fairall, Andrew Jessup, Brian Ward, Christopher Merchant, and Darren Jackson are gratefully acknowledged.

Retrieval Uncertainty Dependencies

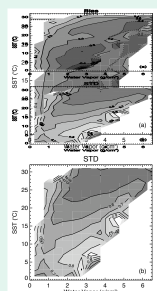
Sources of uncertainty in infrared and microwave SST retrievals are different and highly complementary. Accurate merged products require detailed understanding of the uncertainty dependencies to enable optimal weighting of the different input components.

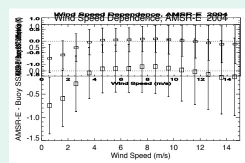
Infrared Retrievals



Biases in infrared retrievals relative to drifting buoy observations exhibited the largest dependencies on water vapor content, satellite zenith angle, SST, and aerosol content.

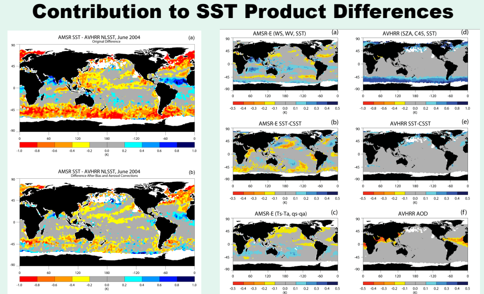
Microwave Retrievals





Microwave retrieval biases relative to drifting buoy observations were observed to be most strongly related to wind speed, SST, and water vapor content.

Contribution to SST Product Differences

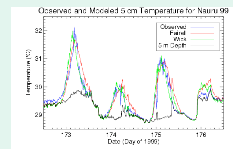


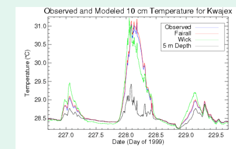
Explicitly accounting for the biases reduces differences between infrared and microwave SST products. The relative impact of the contributions are shown.

Diurnal Warming

Blending observations at different measurement times and effective reference depths requires accurate compensation for diurnal warming at low wind speeds. Different methodologies including detailed physical models and simplified parameterizations have been evaluated, refined, and compared.

Observations and Simulations of Diurnal Warming





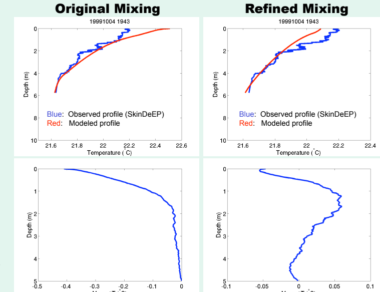
Available numerical models provide overall skill in reproducing observations of diurnal warming within the near-surface layer but typically require complete time series of forcing data.

Model Refinements

Original Mixing | **Refined Mixing**

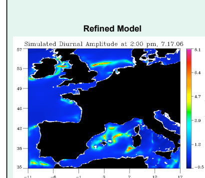
Instantaneous Profiles

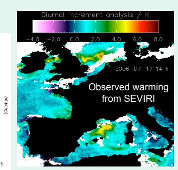
Time-averaged Biases



Improvements to model mixing schemes resulted in reduced biases near the surface.

Model Evaluation with NWP Forcing

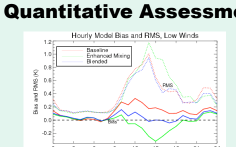


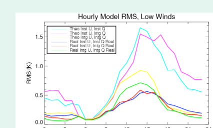


Observations courtesy C. Merchant

Additional tests showed the refined model could reproduce observations of extreme warming using high resolution numerical weather prediction model forcing.

Quantitative Assessment of Model Uncertainty





Comparisons with available cruise data enable quantitative estimates of the accuracy of different diurnal models. While detailed models can have little mean bias, random errors still approach 1 K at low winds. Simplified parameterizations can add additional errors of more than 0.5 K.